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(54) Abstract Title
# Organic light emitting display

(57) A barrier wall end portion 3 connects together the ends of barrier wall lines which are situated at gaps in the upper electrode pattern 5. The barrier wall end portion helps prevent layer delamination and ensures good adhesion between the upper electrodes 5 and the lead-out electrodes 6.

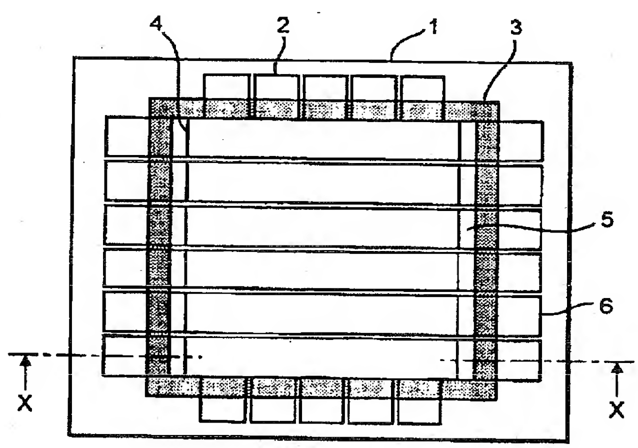


FIG. 1(a)

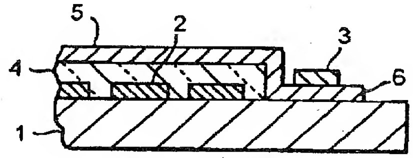


FIG. 1(b)

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

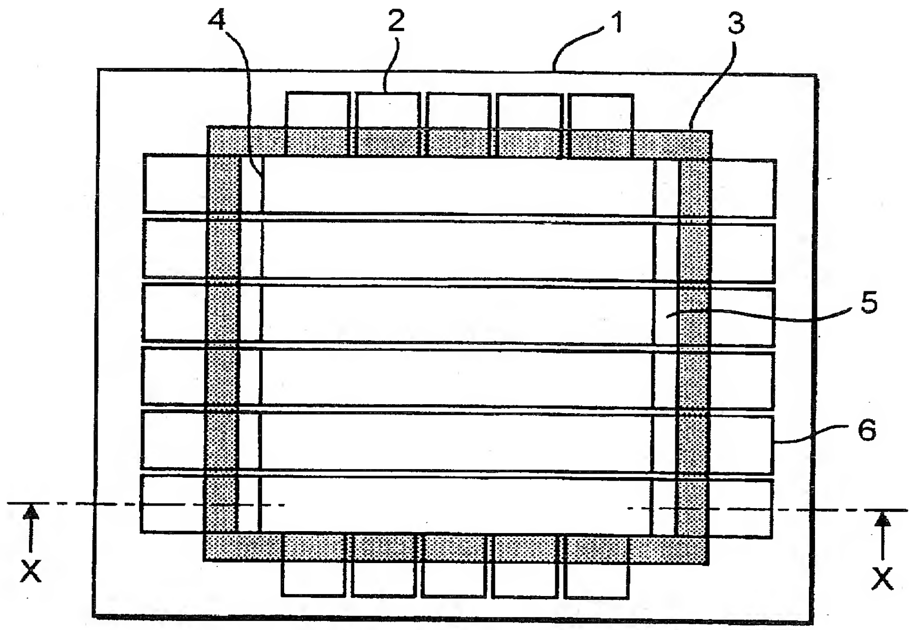


FIG. 1(a)

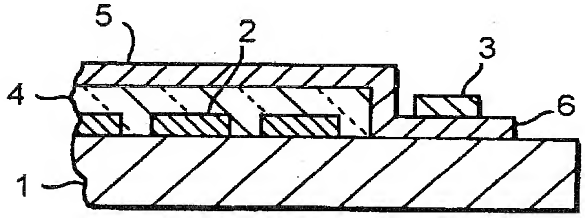


FIG. 1(b)

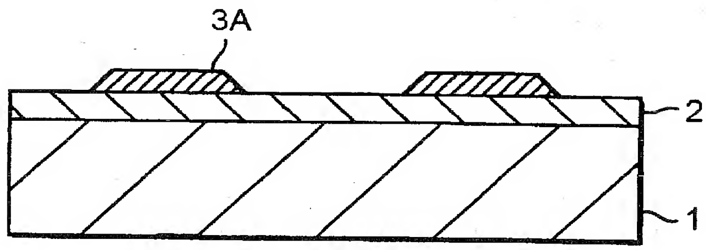


FIG. 2(a)

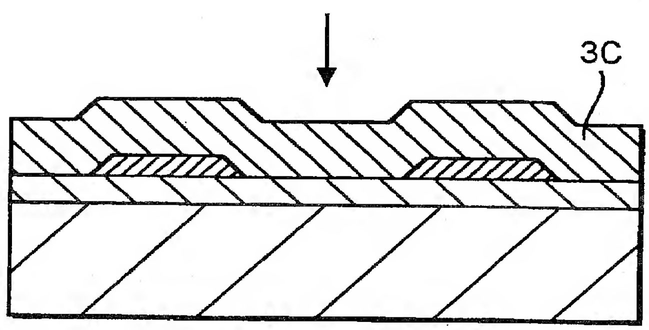


FIG. 2(b)

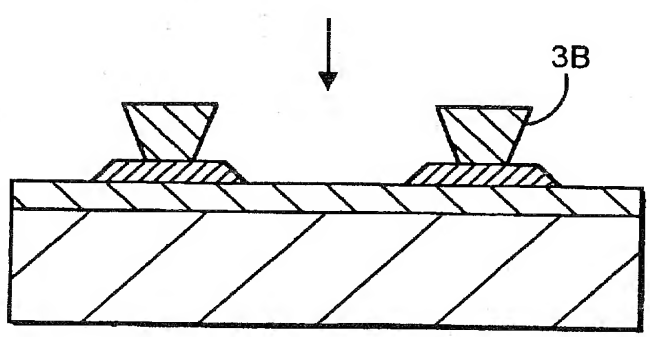


FIG. 2(c)

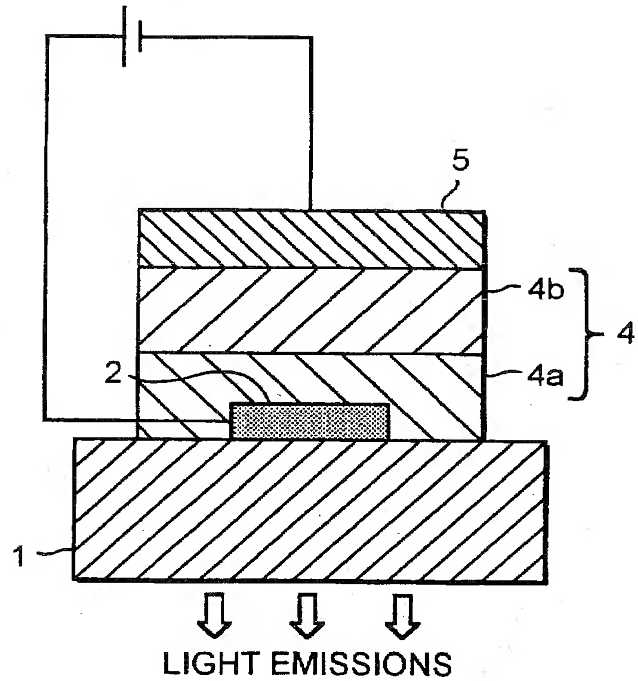


FIG. 3(a)

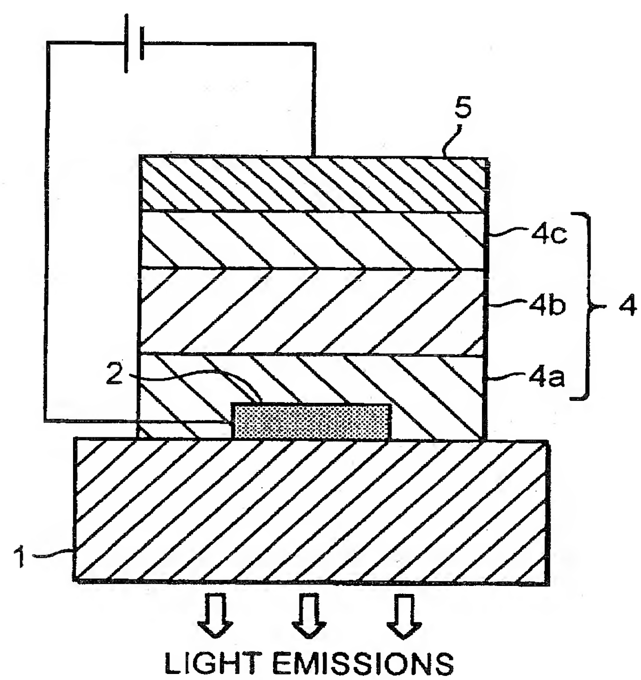


FIG. 3(b)

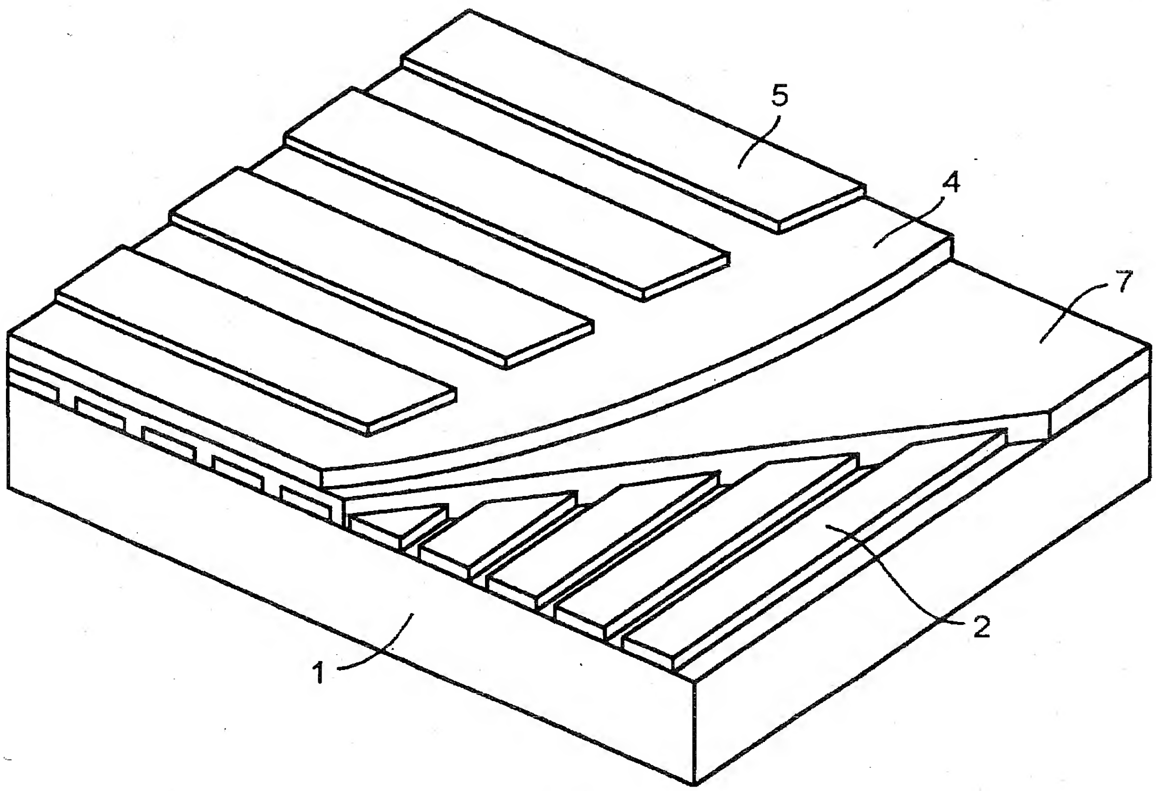


FIG. 4

# ORGANIC THIN-FILM LIGHT-EMITTING DEVICE

The present invention relates to an organic thin-film light-emitting device for use in, for example, a flat-panel display. More specifically, the invention is directed to structure of an organic thin-film light-emitting device that prevents electrical contact between upper electrodes in fabrication process of the device and thus, results high productivity.

An organic thin-film light-emitting device is also called an organic thin-film electroluminescent (hereinafter abbreviated to EL) device. The EL device emits light by recombination of an electron and a hole which are injected to an organic thin-film by applying an electric field. The organic thin-film generally consists of multiple layers.

Figure 3(a) and Figure 3(b) show a conventional organic thin-film light-emitting device. Figure 3(a) is a sectional view of a two-layered type light-emitting device, and Figure 3(b) a sectional view of a three-layered type. The organic thin-film light-emitting device shown in Figure 3(a) is constructed by sequentially forming an anode 2 which is a transparent electrode of ITO (indium tin oxide) deposited on a transparent substrate 1, an organic EL medium layer 4 consisting of a hole transport layer 4a and a light-emitting layer 4b, and a cathode 5 which is a metal electrode. The organic EL medium layer of the EL device of Figure 3(a) is a two-layered type (Appl. Phys. Lett. vol. 51, p. 913, 1987). The organic thin-film light-emitting device shown in Figure 3(b) further comprises an electron transport layer 4c formed between the cathode 5 and the light-emitting layer 4b. The organic EL medium layer of the EL device of Figure 3(b) is a three-layered type. Recently, also known is a four-layered structure in which a hole injection layer is further formed between the anode 2 and the hole transport layer 4a (e.g. SID 97 DIGEST, p. 1073, 1997).

Figure 4 is a perspective view of a conventional organic thin-film light-emitting device.

The organic thin-film light-emitting device is a so-called X, Y matrix type (simple matrix type). The device is fabricated by laminating sequentially on a transparent glass substrate 1, an anode 2 consisting of a

multiple of transparent electrodes made of, e.g., ITO, an electrically insulating layer 7, an organic EL medium layer 4, a metal cathode 5 which constitutes upper electrodes orthogonal to the transparent electrodes. A light-emitting area of the organic thin-film light-emitting device is composed of an organic EL medium layer 4, and a pair of anode 2 and metal cathode 5 which oppose each other and sandwich the organic EL medium layer. One pixel corresponds to an elementary light-emitting area formed by an overlap of a single electrode composing the transparent anode 2 and a single electrode composing the metal cathode 5 orthogonally disposed each other. A flat panel display device comprises a plurality of the elementary light-emitting areas arranged on a substrate of an organic thin-film light-emitting device corresponding to a number of pixels. A flat panel display device operates by driving the organic thin-film light-emitting device via the transparent anode 2 and the metal cathode 5 to which lead wires (not shown) are attached around the flat panel. Patterning of the anode 2 is generally performed by photolithography after forming a film of anode material on a substrate. At first, photoresist is coated on an anode film; then, patterning of the photoresist is performed to a designed configuration via exposure and development; and finally, the anode material is etched and the photoresist is peeled off.

On the other hand, the upper electrodes are very difficult to be patterned by photolithography because organic EL media, such as materials of a charge injection layer and a light-emitting layer consisting an organic EL medium layer, have poor resistance to heat, solvent, or moisture. Japanese unexamined patent application publication (KOKAI) No. H9-320758 discloses a patterning method using a mask for vapour deposition. However, poor adhesion between a substrate and a mask in the method causes a blur due to migration of evaporating material to clearance at the poor adhesion location. In addition, fine patterning with the mask cannot accomplish accurate pattern because the fine mask raises problems such as deflection of the mask due to insufficient rigidity of the mask. Laser processing using excimer laser or YAG laser is considered (Japanese unexamined patent application publication (KOKAI) No. H9-50888). However, this method causes poor productivity due to local difference of workability between places with or without organic material film beneath the cathode

film. The laser processing also causes a short-circuiting an anode with a cathode in which burrs are generated around the cathode line edge by the laser processing. Further, an organic material layer around laser-irradiated location suffers from damage due to laser light.

To solve this problem, a so-called shadow mask method is disclosed in Japanese unexamined patent application publication (KOKAI) No. H5-275172 (corresponding to US Patent No. 5,276,380). In this method, a stripe-shaped array of barrier walls of several to several tens of $\mu$m high are formed in parallel with each other on the ITO-patterned substrate. Patterning of a cathode or an organic EL medium is performed by evaporating material for the cathode or the organic EL medium from the direction perpendicular to the barrier walls or oblique to the substrate surface.

Japanese unexamined patent application publication (KOKAI) No. H8-315981 discloses another method, in which a series of electrically insulating barrier walls are formed on a surface of a substrate bearing ITO lines. The lines of the barrier walls are orthogonal to the ITO lines. The barrier wall has on its top an overhanging portion protruding in the direction parallel to the substrate surface; that is, the barrier wall has an inversely tapered cross section. After the formation of the barrier walls, an organic EL medium layer and a cathode are formed in this order. Each electrode of the cathode is separated by the overhang of the barrier wall and the electrodes at both sides of the barrier wall are electrically insulated with each other. In this method, short-circuiting of an anode of ITO and a cathode is prevented by a means where flow of organic EL medium vapour goes round under the overhang of the barrier wall in a process for light-emission layer formation, and in the following cathode formation process, metal vapour flows around under the overhang of the barrier wall less distant than the organic EL medium vapour goes round. Also disclosed is an insulation film disposed beneath the barrier wall so that short-circuiting of an anode and a cathode, specifically short-circuiting at a cathode edge, is avoided.

The above-cited method performs fine processing of the cathode and the organic EL layer. However, use of photoresist for lift-off in the reverse-tapered barrier walls causes peeling-off of the barrier walls, which raises short-circuiting between adjacent upper electrodes and results in unsatisfactory patterning of upper electrodes.

The present invention has been made in view of the above, and the object of the invention is to provide an organic thin-film light-emitting device comprising barrier walls as a shadow mask in which peeling-off of the walls at their ends is prevented by a structure without free end, and upper electrodes with any desired pattern can be reliably fabricated.

In order to attain the object, the invention provides an organic thin-film light-emitting device having an image display array consisting of a plurality of light-emitting areas, the organic thin-film light-emitting device comprising a substrate, a plurality of first electrodes arranged in parallel on the substrate, an EL layer of organic material formed on an electrode pattern of the first electrodes, a plurality of second electrodes formed on the EL layer, and an electrically insulating barrier wall arrangement consisting of a barrier wall line portion and a barrier wall end portion, the barrier wall line portion including a plurality of barrier wall lines disposed at gaps in an electrode pattern of the second electrodes, and every ends of the barrier wall lines being connected to the barrier wall end portion. No free end is left in the barrier wall lines.

Advantageously, the barrier wall arrangement comprises an insulating film and photoresist for lift-off formed on the insulating film.

Advantageously, the width of the barrier wall end portion is wider than the width of the gaps in the electrode pattern of the second electrodes and wide enough to prevent peeling-off of the barrier wall lines at their ends.

The present invention will be explained hereinafter with reference to the accompanying drawings, in which:

Figure 1(a) and Figure 1(b) show an organic thin-film light-emitting device of the invention. Figure 1(a) is a perspective plan view, and Figure 1(b) is a sectional view taken along line X-X in Figure 1(a);

Figure 2(a), Figure 2(b), and Figure 2(c), show a process for fabricating an organic thin-film light-emitting device of the invention. Figure 2(a) is a partial sectional view illustrating the insulating film, Figure 2(b) is a partial sectional view illustrating the insulating film and the photoresist, and Figure 2(c) is a partial sectional view illustrating the barrier walls;

Figure 3(a) and Figure 3(b) shows a conventional organic thin-film light-emitting device. Figure 3(a) is a sectional view of a two-layered type light-emitting device, and Figure 3(b) is a sectional view of a three-layered type; and

Figure 4 is a perspective view of a conventional organic thin-film light-emitting device.

Referring now to the Figures, a plurality of lower electrodes (first electrodes) 2 made of, for example, ITO is arranged in a stripe shape on a substrate 1. An organic EL medium layer 4 is laminated on the lower electrodes. A plurality of upper electrodes (second electrodes) 5 is laminated in a stripe shape on the organic EL medium layer 4. The upper electrodes are disposed orthogonally to the lower electrodes. Each of the upper electrodes 5 is connected to each of lead-out electrodes 6 having the same width as the upper electrode. Then, a barrier wall end portion of an electrically insulating barrier wall arrangement 3 is formed on the end portion of the lower electrodes 2 and on the lead-out electrodes 6. A barrier wall line portion of the barrier wall arrangement 3 is formed at gaps between the upper electrodes 5 and connected to the barrier wall end portion.

The organic EL medium layer 4 may be either a single light-emitting layer, a two-layer structure consisting of a hole transport layer and a light-emitting layer, or a three-layer structure consisting of a hole transport layer, a light-emitting layer and an electron transport layer. A light-emitting area is a portion of the organic EL medium layer sandwiched by a line of the lower electrodes 2 and a line of the upper electrodes 5 orthogonal to the line of the lower electrodes.

The substrate 1 may be made using a plate of quartz or glass, or a transparent plastic plate of, such as, polyester, polymethacrylate, polycarbonate, or polysulfone. Alternatively, a metal sheet, metal foil, or a plastic film may be used.

In the organic thin-film light-emitting device of the invention, the lower electrodes 2 perform as an anode that injects holes. The anode may be made of indium zinc oxide ($In_2O_3$ + ZnO) as well as the above mentioned ITO (indium tin oxide: $In_2O_3$ + $SnO_2$). In addition, a laminate of one of these transparent conductive films and a metal film may be used.

Although the substrate 1 and the lower electrodes 2 are transparent and light is emitted through the substrate in the above described organic thin-film light-emitting device, the upper electrodes may be made with transparent electrodes and light can be taken out through the upper electrodes. In the latter case, advantageously, the lower electrodes are made of metal, or a reflection film is formed on the substrate surface opposite to the film-laminated surface. The structure enables to take out light more efficiently.

A process for fabricating an organic thin-film light-emitting device of the invention is described below.

Figure 2(a), Figure 2(b) and Figure 2(c) show a process for fabricating an organic thin-film light-emitting device of the invention. Figure 2(a) is a partial sectional view illustrating an insulating film, Figure 2(b) is a partial sectional view illustrating an insulating film and a photoresist film, and Figure 2(c) is a partial sectional view illustrating barrier walls.

An ITO film was formed on a transparent substrate of glass by sputtering method followed by shaping to strips by means of photolithography to obtain lines of transparent lower electrodes 2. The lower electrodes were formed such that each electrode had a film thickness of 100 nm and a line width of 90 $\mu$m and each gap between adjacent electrodes was 20 $\mu$m. Each line edge of the lower electrode was formed tapered. An insulating film of $Si_3N_4$ or $SiO_2$ of about 300 nm thick was formed by means of sputtering or PECVD on the substrate patterned with lower electrode strips of ITO. A film of positive-type photoresist was formed on the insulating film followed by patterning of the photoresist film. Then, lines of insulating film 3A (Figure 2(a)) were formed by patterning the insulating film by means of anisotropic etching, such as dry etching.

After that, a photoresist film 3C (Figure 2(b)) of from 4 to 5 $\mu$m thick was formed using the photoresist for lift-off available under the trade name ZPN1100 from Nippon Zeon Co., Ltd. Then, the photoresist film was exposed and developed so that photoresist lines 3B having an overhanging cross section were formed overlying the insulating film lines 3A. The insulating film line 3A and the photoresist line 3B constituted a

line of electrically insulating barrier wall 3 (Figure 2(c)). The line of electrically insulating barrier wall 3 did not have its free end. Although ZPN1100 was used as photoresist for lift-off in the above described photoresist line 3B, positive-type photoresist SIPR-9691 from Shin'etsu Chemical Industries Co., Ltd. may also be used. A barrier wall end portion of the barrier wall arrangement was formed on lead-out electrodes 6 leaving a part of inside area for connecting upper electrodes 5 to the lead-out electrodes 6. Width of the barrier wall end portion of the barrier wall arrangement was wider than the width of the gap (several tens of microns) between the upper electrodes in order to achieve enough area of overlapping between the barrier wall end portion and the lead-out electrodes 6.

An organic EL medium layer was formed by evaporating organic EL medium material such that any part of the lower electrodes did not expose in pixcel portions on the substrate. The organic EL medium layer was formed by first depositing an organic hole transport layer 4a of N,N'-diphenyl-N,N'-bis(3 methylphenyl)-1,1'-biphenyl-4,4'-diamine (TPD), then depositing a light-emitting layer 4b of tris(8-quinolinol) aluminium (Alq3). The both layers were about 50 nm thick. The upper electrodes 5 formed were films of Al-Li alloy with a film thickness of about 100 nm.

According to the present invention, an organic thin-film light-emitting device having an image display array of a plurality of light-emitting areas comprises a substrate, a plurality of first electrodes arranged in parallel on the substrate, an EL layer of organic material formed on an electrode pattern of the first electrodes, a plurality of second electrodes arranged on the EL layer, and an electrically insulating barrier wall arrangement, wherein the barrier wall arrangement consists of a barrier wall line portion disposed at gaps in the second electrode pattern and a barrier wall end portion which connects the ends of the barrier wall line portion. Because the barrier wall line portion of the barrier wall arrangement is mechanically reinforced by the barrier wall end portion, the barrier wall line portion is prevented from peeling-off, and short-circuiting between adjacent upper electrodes is avoided. Thus, an organic thin-film light-emitting device with excellent productivity is obtained.

## CLAIMS

1. An organic thin-film light-emitting device having an image display array of a plurality of light emitting areas comprising;

a substrate;

a plurality of first electrodes arranged in parallel on said substrate;

an electroluminescent layer of organic material formed on an electrode pattern of said first electrodes;

a plurality of second electrodes formed on said electroluminescent layer; and

an electrically insulating barrier wall arrangement consisting of a barrier wall line portion and a barrier wall end portion, said barrier wall line portion including a plurality of barrier wall lines disposed at gaps in an electrode pattern of said second electrodes, and every ends of said barrier wall lines being connected to said barrier wall end portion.

2. An organic thin-film light-emitting device according to claim 1, wherein said barrier wall arrangement comprises an insulating film and photoresist for lift-off formed on said insulating film.

3. An organic thin-film light-emitting device according to claim 1 or claim 2, wherein width of said barrier wall end portion is wider than width of the gaps in the electrode pattern of said second electrodes and wide enough to prevent peeling-off of said barrier wall lines at ends thereof.

The Patent Office

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**Application No:** GB 0003652.5
**Claims searched:** 1-3

**Examiner:** SJ Morgan
**Date of search:** 11 July 2000

# Patents Act 1977
# Search Report under Section 17

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): H1K(KEAP,KEAL); G5C (CHE)

Int Cl (Ed.7): H01L 27/00, 27/15, 51/20; H05B 33/10, 33/12, 33/22

Other: WPI, JAPIO, EPODOC

**Documents considered to be relevant:**

| Category | Identity of document and relevant passage | Relevant to claims |
|---|---|---|
| A | US 5 701 055 (PIONEER) | |

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|---|---|---|---|
| X | Document indicating lack of novelty or inventive step | A | Document indicating technological background and/or state of the art. |
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